Appropriation of value in Biomedical research outcome at Public Research Organisations

by

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Abstract

Transactions on biomedical research outcomes bring into play strategies that are determined by leveraging resources into quasi-markets and on options based on expectations. To govern such transactions, the choice of appropriate governance structures and the governance of interaction are all too often in remittance of risk and uncertainty. Organisation and communities are prompted by issues concerning intellectual property (IP) to underwrite information, which is inherently fraught with difficulties of discerning ownership and quantifying qualitative business variables. Against that backdrop, we enquire on the mechanisms underpinning value dissipation and value appropriation of biomedical research outcomes to make proposition on the organisational antecedence to innovation. It is a preamble study with the view to developing a meso-level framework to describe mechanisms of value appropriation of upstream biomedical (non-invasive) research at Public Research Organisation. Its underpinning is largely based on the availability appropriability regimes and viability of organizational governance decisions and *how the choice of organizational governance form affects both the creation and appropriation of economic value*.

Keywords: value appropriation, knowledge protection, quasi-rents, networks, innovation.

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I. Introduction

Opportunities to generate and appropriate economic rents from biomedical research and development (R&D) exist because of competitive imperfections in factor or product markets. This can be achieved by utilizing isolation mechanisms, such as those protecting knowledge assets. Value isolating mechanisms impose constraints on information diffusion and can take many different forms, including patents, copyrights, non-compete clauses, and so forth. They are means of protecting information and used as a tool by economic actors to prevent, or at least delay, duplication of its intellectual assets. This, in turn makes it possible to earn (temporary) monopoly rents, and also ancillary profits (such as licensing and routes to public funding). As a practical matter, knowledge protection has been traditionally linked to the notion of appropriability (Arrow, 1962; Nelson and Winter, 1982; Zander and Kogut, 1995), which continues to be relevant (Arora, 1997; Pitkethly, 2001; Nieto and Pérez-Cano, 2004; Durack, 2004; Hurmelinna *et al*., 2007). However, the capacity of appropriability mechanisms (efficacy) to create temporary monopoly rents and other benefits for a firm (efficiency) contends with a well established view that knowledge emanating from research exhibit certain specific properties: uncertainty, inappropriability and indivisibility (Nelson, 1959; Arrow, 1962, Lipsey and Carlaw, 1998). As a result, it is commonplace that appropriability attempts are inherently fraught with issues concerning valuation, particularly at the early phases when decision-making is under conditions of uncertainty about future prospects.

Fundamentally, the ability to realize rent-generating potential poses problems concerning the assembly of necessary resources and to appropriate at least some of the rents that will be generated when they take advantage of these opportunities (Alvarez and Barney, 2004). These involve issues of ownership and control that require the distinction between underlying knowledge, intellectual property (IP) assets and endowed rights, IP rights, (IPR) (Pitkethly, 2001). With the growing complexity of technological innovation that is spread over different stages in a value chain, appropriation is aggravated by the likelihood that many patents covering these technological components may be controlled by many different owners and can thus turn into IP roadblocks. The transaction associated costs has attracted concerns in biomedical research, where Heller and Eisenberg (1998) call this ‘the tragedy of the anti-commons’.

Against that backdrop, appropriation concerns and coordination requirements have become powerful concepts in IP management by jointly describing the need to manage the creation and safeguard the appropriation of value (Tomkins, 2001). Competition, in turn, invokes an emphasis on the renewal of IP assets in accounts that takes heed of the increasingly discontinuous nature of innovations (Bartlett and Ghoshal, 2002; Zahra and Nielsen, 2002; Lovas and Ghoshal, 2000; Markides and Geroski, 2003). The use of organizational forms such as distinctive use of networks and increasing employee mobility, further prompts issues concerning knowledge mobility and network stability (Pisano, 1990; Kale *et al*., 2000; Teece, 2000; Sakakibara, 2002; Dhanaraj and Parkhe, 2006).

Appropriability has thus been identified as a strategic success factor for organisations that produce research and development (R&D). It includes the establishment of an effective an environmental factors, known as an

appropriability regime, which can in turn facilitate taking profit from innovations (Teece, 1986: 610; Brockhoff, 2003; Hurmelinna *et al*., 2007).

Under such dynamic conditions and the rise of the university-industry collaboration, the management of IP assets and IPR deriving from research universities and research centres funded by public funds (collectively Public Research Organisations or PRO) have evolved from processes of (i) an "Open Science model", in which PROs did not retain or enforced certain types of IPR, through (ii) a "Licensing Model" in which the PROs started to retain, protect and commercialise inventions based on their discoveries, essentially through licensing the IPR to industry or to start-up companies, and into (iii) the "Innovation Model" in which the licensing model has been supplemented by a active collaborative research with industry and a pro-active involvement in the creation of spinout companies (Roper *et al*., 2004; Siegel *et al*., 2003; Lee and Win, 2004; Gloet and Terziovski, 2004; European Union, 2004). All three models are in use at PROs to strategically manage spill-over, and in turn provide a forum to acquire funding, incentive mechanisms and diffusion, both with regard to research findings in general and to particular innovative technologies that are ready for practical application. Within that remit, research at Universities has been acknowledged to be conducted within different frameworks of knowledge production systems, and 'in the context of application' (Gibbons *et al*, 1994; Huff, 2000; Nowotny *et al*, 2001; Kurek *et al*., 2007).

Our study analyses the issue of appropriability and in particular of mechanisms carried out to earn quasi-rents in biomedical research outcomes. This work is mechanisms to organize rent generation and appropriation along three dimensions (1) the extent to which activities and the desired contributions are amenable to codification (*ex-ante* uncertainty); (2) the extent to which alternative uses of investment made to support the activities involve opportunity losses (the degree of asset specificity); and (3) the ability to assess the true quality of actual delivered performance of activities (*ex post* information asymmetry). The article is organised as follows: Section II establishes the background of the problem and framework for the enquiry, as well proposition that were enquired on. This is followed by a description of the sample of specialist and the empirical methodology followed in section III. Subsequently, we present our findings and discuss the main conclusions drawn from this in Section IV and suggest some directions for future research.

II. Background

II.I Biomedical Knowledge and IP

Recent advances in biomedical sciences have changed the way in which innovation occurs. In what has been termed 'the information paradigm', the basis for appropriating value in biomedical-related information features static and dynamic elements, of which anticipated future prospects is augmented by an increasing degree of complementarities, applicability and centrality of biomedical research knowledge and disease processes, or opportunities for medical intervention from a functional perspective (Kost, 1995; Semsarian and Seidman, 2001; Massoud and Gambhir, 2003; Nunn, 2008; Blasberg, 2003; Jaffer and Weissleder, 2005; Gross and Piwnica-Worms, 2006). The dynamic conditions of upstream R&D is fitting to Eisenhart's (1989) notion of high velocity

and D'Aveni's (1994) concept of hyper competition, where advancements are increasingly of a discontinuous nature. As a result, simultaneous innovation results in the fragmentation of IPR that is networked (Rahnasto, 2003; Varian *et al*, 2004), and held by multiple owners. A recognition of this hold-up problem and, also of previous acknowledgment that know-how transfer underpins technological progress, enterprise growth and renewal, both inside and outside a firm (Harrigan and Dalmia, 1991; Appleyard, 1996; Zucker *et al*., 1996), has prompted the use organizational forms such as 'networks' to access new technologies and their associated know-how to improve innovation capacity (George *et al*, 2002, Hagedoorn and Duysters, 2002). As a result, task characteristics have been shown to influence appropriation concerns, as more complex and uncertain tasks lead to increasing contracting difficulties (Heller and Eisenberg, 1998; Anderson *et al*., 2000). Under the strains of technology and regulatory, pre-clinical development have less than a 1 percent chance of commercialization (Rothaermel and Deeds, 2004). Tomkins (2001) described two similar management problems in relationships, alliances and networks, which he labels 'the generation of trust' (i.e. the management of appropriation concerns) and 'the mastery of events' (i.e. the coordination of activities). This resonates with previous findings the outcome, behaviour and social control are often equated with the conceptions of governance (Adler, 2001; Ouchi, 1979) and are useful mechanisms for both managing appropriation concerns and coordinating interdependent tasks. The network context of biomedical research brings into play the appropriation of IP assets emerging at the interstices of communities and networks of practice in upstream biomedical value chains (Scherer *et al*., 1959; Mansfield *et al*., 1981; Mansfield, 1986; Levin *et al*., 1987; Scherer and Ross, 1990; Arora, 1997; Grindley and Teece, 1997; Arundel and Kabla, 1998; Cohen *et al*., 2000; Arundel, 2001; Ducor, 2000; Tomkins, 2001; Cohen *et al*., 2002; Graham *et al*., 2002; Hertzfeld *et al*., 2006). Under such condition, coordination becomes imperative in the consideration of market failure (disclosure dilemma) or fears of opportunism (consequences of appropriation of knowledge by an alliance partner).

Within that premise, Beugelsdijck and Cornet (2001) suggest a useful distinction between two types of knowledge spillover that is also useful in our context of study: rent-based spillovers mediated through market mechanisms, and pure knowledge spillovers which result from un-priced knowledge exchange. For this study, our interest is in the coordination of IP assets shaping both types of knowledge spill-over and their management (i.e. identification, development and exploitation) and how they facilitate the appropriation of value (Dietz and Bozeman, 2005). It is premised on the consideration of market failure (disclosure dilemma) and fears of opportunism (appropriation of knowledge by an alliance partner) and seeks to investigate how PROs deploy governance alternatives as a framework for appropriation by asking the following research question:

1. How do available and effective means to protect intangibles and innovations facilitate the appropriation of value in upstream R&D?
    a. How does the choice of appropriation instruments strengthen the protection of IP assets?

    b. How the organisational structures impinge on appropriation efforts?

To help answer these questions, we start by presenting available methods discussed in the extant literature and subsequently deduce our propositions.

II.II Appropriation

Under the open, licensing and innovative models of University appropriation, economic actors can appropriate value in their biomedical research outcomes by participating in continuous innovation, which enables them to acquire and maintain a position of technological leadership (Levin *et al*., 1987; Harabi, 1995; Brouwer and Kleinknecht, 1999; Arundel, 2001; Cohen *et al*., 2002; West and Iansiti, 2003). By default, it can be assumed that scientific actors at PRO specialising on a subject-matter have expertise in that field. Coupled to bounded rationality and when scientific actors through specialisation are able to comprehend the underpinning of their subject area, the complexity of technology also becomes a viable mechanism of appropriation (March and Simon, 1958; Brouwer and Kleinknecht, 1999). The tacit nature of relevant knowledge underlying an intellectual asset implies that complexity serve an appropriation role due to tacitness, causal ambiguity, or social complexity (Barney, 1991; Nonaka, 1994). By virtue of their expertise, scientific actors may also be in possession of complementary assets critical for innovations and that has been shown to present a forum for appropriating value (Teece, 1987; Cohen *et al*., 2002; Nieto and Pérez-Cano, 2004; Galende, 2006). Fundamentally, it is both the choice and method of disclosure that may determine the effects of an appropriability regime on disclosed information. Nonetheless, as the decision to disclose information is often made early in the life of the information and under conditions of uncertainty, the true effect amongst the different mechanism often becomes known at later stages. Against that backdrop, there is an established view industrial secrets are of greater use as opposed to say patents as a protection mechanism (Harabi, 1995; Brouwer and Kleinknecht, 1999; Arundel, 2001; Cohen *et al*., 2002; Davis, 2001; Hannah, 2005). However, as we shall come to discuss, this may not always the case. On the one hand, protection methods allow economic actors to prevent, or at least delay, duplication of its intellectual assets, which in turn makes it possible to earn (temporary) monopoly rents, and also ancillary profits (such as licensing). On the other hand, the current IP regime does not depart from its implicit function to serve as an organisational role of: (i) acting as an incentive system for innovation; (ii) packaging IP assets; (iii) diffusing technical information; and (iv) controlling IP assets.

Ultimately, it is the use of IP asset in innovation and issues associated with its use that determines the due efficiency of an appropriability regime. According to Pitkethly (2001), the appropriation of value can be view along three dimensions (Figure 1):

----------Insert figure 1----------

- Legal appropriability: value increases as its associated IPRs grow stronger because of a pronounced broadness of its asserted claims if the broad claims are enforceable. As a result, it is awkward for inventors who have to “work around” the patent; thus it deters imitation.

- Strategic appropriability: value increases as a firm becomes more strategically effective at configuring the pattern of strategic resources necessary to market a product successful in the competitive arena of the value chain stage. Therefore, beyond legal appropriability and control over critical complementary assets, strategic appropriability is an essential consideration to competitive positioning within a given value chain.

- Competitive position. Value increases as a firm becomes more capable within the competitive arena of a value chain stage of achieving a favourable position. Thus there is a historic element as value in use is moderated by the previous business success of a firm or productive entity.

Among available and effective means of appropriating value, formal private property rights, especially patents, copyright, and trade secrets have been among the most studied mechanisms (e.g. Jain 1996; Arundel & Kabla 1998; Arundel 2001; Pitkethly 2001; Knight 2001; Kelley & Rice 2002; Cohen *et al*. 2002; Gallini & Schotchmer 2002; Hannah 2005). For highly complex sectors such as the biomedical field, the tacit nature of knowledge is in itself a means of appropriation (Polanyi 1966; Lippman & Rumelt 1982; Nelson & Winter 1982; Dierickx & Cool 1989; Barney, 1991; Zander & Kogut 1995; Teece 1988; 1998; Saviotti 1998). There is also the use of lead-time (Levin *et al*. 1987, 1988; Lieberman & Montgomery 1988; Schoonhoven *et al*. 1990; Mueller, 1997; Makadok 1998; Coerderoy & Durand 2004; Carow *et al*. 2004), which can be instrumental in both private and public domain. Time-critical claims to originality and authorship of knowledge, within the remit of both formal and informal rules governing such claims can also create a route to public funding for coming first. In the private domain, this is also critical form of appropriation, because IP erodes over time through circumvention, duplication and/or obsolescence.

Human resource management and contracts are also a distinct means of appropriation, securing IP rights explicit terms (Rousseau & Wade-Benzoni 1994; Baughn *et al*. 1997; Liebeskind 1997; Boxall, 1998). Finally, the use of practical and technical means of concealment such as encryption and firewalls are widely used both in private and public sectors (Davis, 2001; Hannah 2005). These are common for the protection of genomics and bioinformatics information, where it is commonplace to combine an open science model to click-wrap licensing.

The combination of these forms in an appropriability regime underpins the protection of IP assets and innovations, their profitability, and the increased rents due to R&D (Teece 1984, 1986, 1988; Cohen & Walsh 2001; Harvey and McMeekin, 2004). Their selection of an appropriate regime requires a distinction between IP assets and IPR to delineate ownership and control of underlying IP assets through legal enforcement and credible commitments. Under certain conditions, the type of IPR and a combination of other available methods may be required to attain sufficient protection. In particular, the network context of biomedical research also brings into play the appropriation of IP assets emerging at the interstices of communities and networks of practice in upstream biomedical value chains (Scherer *et al*., 1959; Mansfield *et al*., 1981; Mansfield, 1986; Levin *et al*., 1987; Scherer and Ross, 1990; Arora, 1997; Grindley and Teece, 1997; Arundel and Kabla, 1998; Cohen *et al*., 2000; Arundel, 2001; Ducor, 2000; Tomkins, 2001; Cohen *et al*., 2002; Graham *et al*., 2002; Hertzfeld *et al*., 2006). Under such condition, coordination becomes imperative in the consideration of market

failure (disclosure dilemma) or fears of opportunism (consequences of appropriation of knowledge by an alliance partner).

Summarised, a decision on which protection method to select depends on factors such as:

- the institutional framework (Kortum and Lerner, 1999; Granstrand, 1999; Hall and Ziedonis, 2001; Pitkethly, 2001; Cohen *et al*., 2002; Hurmelinna *et al*., 2007);
- the national and international legal system (Ordover, 1991; Kortum and Lerner, 1999; Shapiro, 2001; Cohen *et al*., 2002; Graham *et al*., 2002; Hurmelinna *et al*., 2007);
- the structure of the industry in which (Scherer *et al*., 1959; Mansfield *et al*., 1981; Mansfield, 1986; Levin *et al*., 1987; Scherer and Ross, 1990; Arora, 1997; Grindley and Teece, 1997; Arundel and Kabla, 1998; Cohen *et al*., 2000; Arundel, 2001; Cohen *et al*., 2002; Graham *et al*., 2002; Hertzfeld *et al*., 2006);
- the dimensions of technological knowledge (Arora, 1997; Pitkethly, 2001; Nieto and Pérez-Cano, 2004; Durack, 2004; Hurmelinna *et al*., 2007; Hertzfeld *et al*., 2006);
- characteristics specific to innovation strategies (Levin *et al*., 1987; Arundel and Kabla, 1998; Cohen *et al*., 2000 and Cohen *et al*., 2002; Arundel, 2001; Galende, 2006) and organisational resources (Maurer and Zugelder, 2000; Hurmelinna *et al*., 2007; Galende, 2006; Hertzfeld *et al*., 2006).

III. Research model and propositions

A determination of what can and should be appropriated requires an initial assessment of what rights are protectable through disclosure and what information qualifies as a trade secret. At PROs, several factors determine who owns the underlying IP assets and what right can be acquired. These factors include whether

1. There are express or implied agreements to assign ownership
2. The inventor is employed by the PRO
3. The inventor made the invention within the scope of their employment
4. Where and when the invention was made.

The attributes of knowledge affect the organization and governance of transaction on information and has become a major challenge of appropriating biomedical information based on three key decisions: (i) whether or not to file for a patent; (ii) whether to market the invention to an existing firm or not; and finally (iii) how (temporary) monopoly rents and ancillary profits are to be structured. These decisions must be based on sound information about the market, the uniqueness and usefulness of the invention and/or technology, the likelihood of being able to obtain patent protection, factors related to the inventor, and the potential paradoxically impact of the of patenting on the institution’s responsibilities.

Under the open, licensing and innovative models employed at PROs to manage their IP, a useful distinction is provided by Beugelsdijck and Cornet (2001), who distinguishes between rent-based spill-over mediated through market mechanisms and pure knowledge spill-over which result from un-priced knowledge exchange. In order words, disclosure may serve to signal and thereby reduce informational asymmetry between firms and outsiders, such as investors (Shapiro, 2001; Long, 2002). Disclosure may also serve multiple functions, for instance add value to the exploitation of undisclosed IP assets by making it readily exploitable to those who desire the underlying IP assets (Hargadon, 1998, 2003; Kodama, 1992). On that basis, the framework for the present study is the process by which research outcome (information- input) can be appropriated along three dimension (Strategic, legal, competitive) to acquire (temporary) monopoly rents, and also ancillary profits (figure 2).

----------Insert figure 2----------

Implementing IP strategies focuses attention on the actual process of IP creation, development and protection (Hanel, 2006). First we distinguish between organisations. Differences in organisational context, and contrasts between the types of R&D being conducted in the different types of PROs, suggest our first set of propositions:

Proposal 1: IP management practices will differ between university-based and research centres funded by public funds.

Proposal 2: IP management practices will differ between university-based PROs depending on which IP model they adopt.

Proposal 3: PROs will implement incentives for the creation and identification of IP which reflect the nature of the host organisation and the IP model being adopted.

As suggested earlier, however, different types of PROs in different settings are likely to devote differing levels of resources to IP protection and development. For example- University based PROs may find it difficult to invest the level of resources necessary to protect their IP effectively and may adopt alternative commercial strategies to maintain their technological leadership (Blackburn, 2003; Bigliardi *et al*., 2006). This leads to us to make proposals on the use of appropriation mechanisms:

Proposal 4: Use of formal IP protection methods will depend on the organisational background of the PRO

Proposal 5: PROs will use specialist services to support their IP protection and exploitation strategies. Use of these services will reflect the nature of the host organisation and the IP model being adopted.

Inter-organizational innovation networks are providing opportunities to exploit superior resources that reside beyond the boundary of the firm (George *et al*, 2002, Hagedoorn and Duysters, 2002). The appropriability

regime in an innovation network thus influence PROs appropriability regime, and is influenced by, network stability. Research has shown that equity often plays a critical role in enhancing both the appropriability environment and the stability of such relationship by mitigating the competitive dynamics and opportunistic behaviour that can lead to premature dissolution of alliances (Beamish & Banks, 1987; Park & Russo, 1996). In the context of this research, our focus is on joint asset ownership and we enquire on how they ensure equitable distribution of value in stable network, processes that enhance reputation and multiplexity not only induce stability in a network but also contribute to trust and openness within the network. This approach associates appropriability regime with networks, where it has been found that the strength of the appropriability regime and the stability of the network are mutually reinforcing and will have a reciprocal relationship (Dhanaraj and Parkhe, 2006). Thus, we propose that:

Proposition 5: Innovation appropriability in an innovation network will positively impact knowledge mobility in the network.

Proposition 6: Innovation appropriability will positively impact the stability of innovation networks.

Proposition 7: Stability of innovation networks will positively impact the strength of innovation appropriability.

Ex-ante codification (uncertainty), asset specificity (opportunism), and *ex-post* monitoring (information asymmetry)

Given that appropriability can not be measured directly, we enquire appropriation using a framework characterised along three dimension- *Ex-ante codification, asset specificity and ex-post information asymmetry* (figure 3).

----------Insert figure 3----------

Upstream biomedical R&D is epitomised by scientific exchange of information that is often tacit and non-proprietary. This type of knowledge is based on their expertise (Brockmann and Anthony, 2002; Dyer and Hatch, 2004; Howells, 1996; Roberts, 2000), of which wider legal definition is as follows:

> Information, including a formula, pattern, compilation, program, device, method, technique or process, that:
>
> (i) derives independent economic value, actual or potential, from not being generally known to, and not being readily ascertainable by proper means by,

other persons who can obtained economic value from its disclosure or use, and

(ii) is the subject of efforts that are reasonable under the circumstances to maintain its secrecy.

Know-how transfer underpins technological progress, enterprise growth and renewal, both inside and outside their own firm (Harrigan and Dalmia, 1991; Appleyard, 1996; Schrader, 1991; Zucker *et al*., 1996; George *et al*, 2002, Hagedoorn and Duysters, 2002). It plays a crucial role in the pooling of assets and as an organizational level activity and portrayed as a 'network approach' to innovation (Hankasson, 1990; Bower, 1993; George *et al*, 2002, Hagedoorn and Duysters, 2002; Coombs and Metcalfe, 2002). Previous work on the know-how transfer has focused on decision making cues founded on the expectation of reciprocity (Dutton and Jackson, 1987; Pfeffer and Salancik, 1978). Expanding on this view, recent work shows that the effects of different contextual cues, such as competitiveness, social relationship, boundaries within or across firm have a summative effect upon the expectation of reciprocity and know-how transfer (Kackra and White, 2008).

In the context of this study, we are concerned in whether the flow of information is amenable to *ex-ante* codification (uncertainty), or becomes the subject of asset specificity (opportunism), and whether it can be monitored *ex post* (information asymmetry). By definition, know-how knowledge is tacit and as such difficult to codify (Schrader, 1991). At the same time, its is not often subjected to formal bars. Rather, it is knowledge embedded in an individual's concrete expertise (Hansen, 1999; Polanyi, 1966), and may not be documented from available sources. As a result, the appropriation of value in know-how requires an investment of time and resources to curtail an economic that may be uncertain and difficult to specify or value, *ex ante* (uncertainty) or to monitor and enforce *ex post* (information asymmetry) (Appleyard, 1996; Pfeffer, 1981; Schrader, 1991). Its transfer also may serve to establish a competitor (opportunism) with respect to exploitation of the underlying IP asset- know-how information. In other words, exclusive control over know-how information is difficult to maintain *ex post* monitoring.

Spill-over can somewhat be control when know-how is made the subject of transaction. Confidentiality of the know-how information is typically one of the conditions under which trade secret information is transfer. However, if such trade secret information is not properly monitored, marked and otherwise kept secret by the recipient/licensee, there is a clear potential for its loss to third parties or spill-over. It creates a situation where no distinction can be drawn between rent-based spill-over mediated through market mechanisms and pure knowledge spill-over which result from un-priced knowledge exchange (Beugelsdijck and Cornet, 2001). In acknowledgment of this problem, organizational and transaction cost theorists argue that information and know-how transfers are best handled within a firm's boundaries, where the transaction costs associated with know-how exchange may be lower than between firms (Allen and Cohen, 1969; Tushman, 1977; Von Hippel, 1987; Zucker et. al., 1996). The distinction between IP assets and IPR further emphasises that appropriation mechanism within corporate boundaries serves a better means of protecting information. For example, the *SNP consortium* achieves this by filing patents to maintain information as a pre-competitive resource using an open

science model. Patents are filed as evidence of the date of discovery, prior to releasing information, but are later abandoned and ensuring a specific depiction of – copyright- to serve its intended purpose.
This leads us to propose that:

Proposal 8: Internally deployed mechanism better serves the purpose of appropriating value in upstream R&D knowledge/ information prior to transfer.

When the know-how is explicit, proprietary, such as is the case with patent, an exclusive right of limited duration over a new, non-obvious invention of industrial application, is granted in return of publication of the invention. Here, the distinction between underlying IP assets and IPR presents an opportunity to refer specifically to a particular embodiment on which exclusive rights is to be sought and to different embodiments may be referred to in the underlying IP asset. In preparing a patent application, some of the knowledge becomes codified and its potential becomes clearer- an example of *ex-ante* codification. An effect of *ex-ante* codification is that the knowledge attribute of information about the underlying IP asset may mean that information asymmetries between managers-scientist and manager-investors (as well as rivals) may persist well after knowledge is codified in a patent application. In order words, the knowledge creation process begins with tacit knowledge, which implies that lead-time can serve as an asset accumulation or appropriation means supported by the scientist and for that matter serve as an isolation mechanism to keep technologies from rivals (Nonaka, 1994; Polanyi, 1962; Dierickx and Cool's, 1989). Moreover, a disclosed inventive step linking different embodiments can be viewed as signals of future economic performance, for which an open reflection of codified knowledge representing an underlying tacit and complex knowledge may be critical to subsequent innovations or to commercialization (Lippman and Rumelt, 1982; Ahuja and Lampert, 2001; Long, 2002). The tacitness of this information at the early stages of appropriation ensue that value is retained up until the decline of information asymmetric with rival. On that, we propose that

Proposal 9: The combination of legal enforcement (trilateral) and credible commitments (bilateral) serves a greater purpose of appropriating value.

Fundamentally, disclosure serve the purpose of signalling (Long, 2002), and given the informational asymmetry between PRO and outsiders, PROs need to signal their expertise and use the IPR system to do this. Patents, in particular, are costly to acquire and undergo an external quality check, hence they act as good signals, allowing firms to raise finance or attract talented employees. On the hand, know-how has been shown to play a role in leveraging business resources (Teece, 1987; Cohen *et al*., 2002; Nieto and Pérez-Cano, 2004; Galende, 2006). The signal effect of disclosure presents a forum to collaborate with others. The profitable transfer of ideas from where they are known to where they represent more innovative possibility conjure value creation and the appropriation of value, as well as quicken the pace of innovation (Hargadon, 1998, 2003; Kodama, 1992). On that note, we propose that:

Proposal 10: Know-how transfer, predicated on appropriation regime will positively impact value creation

Know-how has been acknowledged to flows best through trusting communities (Adler, 2001), where strong social relationships between individuals are often associated with the transfer of complex knowledge (Hansen, 1999; Szulanski, 1996; Tsai and Ghoshal, 1998). In view of the foregoing, we propose that

Proposal 11: Know-how transfer, predicated on appropriation regime will positively impact the stability of partnership

The effect of rival's patent gives an advantageous position to the detriment of the focal firm, with 'spill-over' effects, when a breakthrough by a rival firm triggers greater technological opportunity and provides information on which the focal firm can build. Strategically, the possibility of technology spill-overs is increased since, before a patent can be granted, the inventor must make public detailed technical information about the invention, including claims of novelty. Therefore information asymmetry between inventors is reduced, which Scotchmer (1991) describes using the phrase 'standing on the shoulders of giants' as a means to describe the phenomenon of an inventor who achieves the last stage in a breakthrough. This can play a role in strategically appropriation to carve the way for asserting a competitive position even where others have contributed many of the fundamental building blocks of the technology. Thus, we propose that:

Proposal 12: Legal appropriation has a positive impact on strategic appropriation

This type of activity is reminiscent of the innovative model and participation can serve the purpose of allowing PROs to play a part in broader technology-exchange agreements between large firms, also known as 'patent pools' (Baumol, 2002). This not only provides PROs in the patent pool with a degree of protection against firms outside the technology agreement, but also counters the effect of creating a 'patent thicket' (Shapiro, 2001).

Proposal 12: Legal appropriation has a positive impact on competitive positioning

Within the framework of open, licensing and innovative models, there are therefore several possibilities to appropriate vale in research outcomes.

IV. Conclusion and future work

It was implicit in our analysis that the mechanism of appropriation and capacity of certain appropriability mechanisms can take several dimensions. This is in acknowledgement that knowledge emanating from research exhibit certain specific properties: uncertainty, inappropriability and indivisibility (Nelson, 1959; Arrow, 1962, Lipsey and Carlaw, 1998). Therefore appropriability serves to enable to the distinguishing between the governance of choice and interaction by way of legal enforcement and credible commitments as a mechanism of modulating rent-based spillovers mediated through market mechanisms, and pure knowledge spillovers which result from un-priced knowledge exchange (Beugelsdijck and Cornet, 2001).

The next logical step in our analysis is to builds theory from the framework looking at the mediation of open, licensing and innovative models deployed at PROs to manage IP assets. Starting point for the theoretical base of

the study is a process model of entrepreneurial processes based on social system theory, which is used in the research program of Nikos (Groen, 2005). This will be combined by insights from technology dynamics (Rip and Groen, 2001). Actions of actors involved in the development networks will be analysed on the basis of the four function model underlying the social system theory (goal attainment, pattern maintenance, adaptation, integration). The combination allows for a study of strategic, cultural, social, economic and technological value creation aspects of business development processes (Groen, *et al*, 2002).

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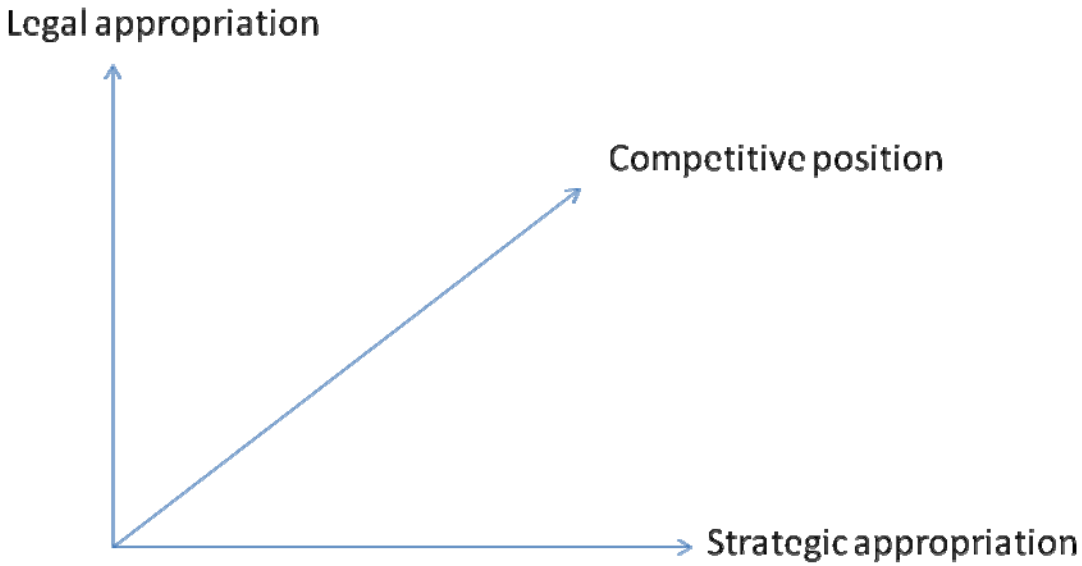

Figure 1: The dimension of appropriation (Pitkethly, 2001)

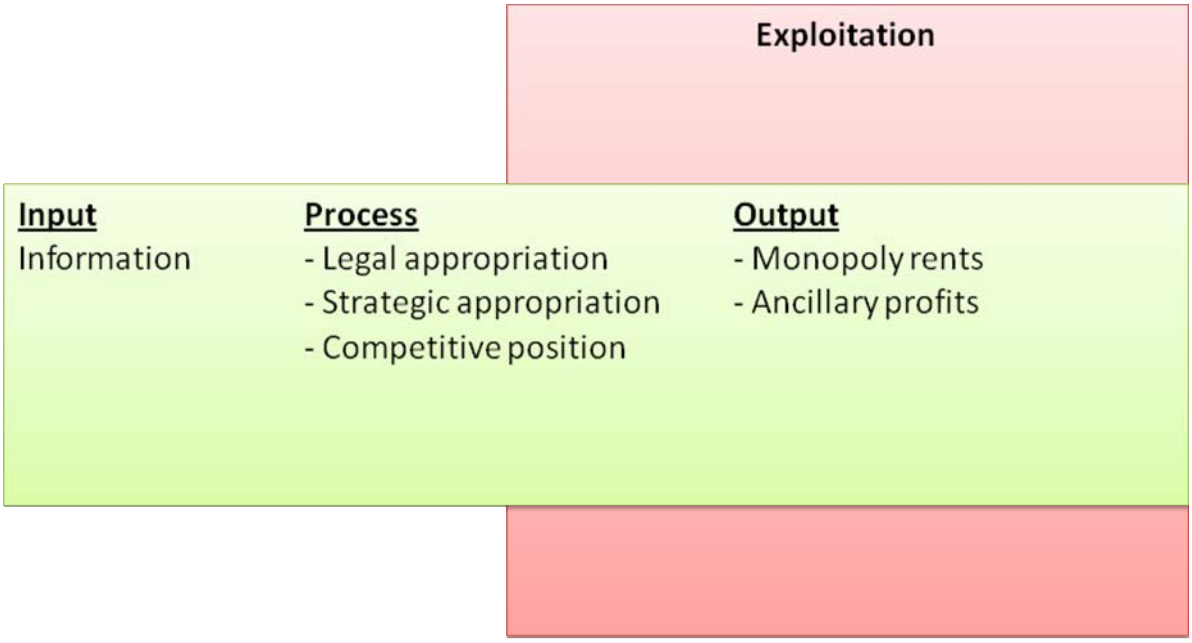

Figure 2: Research framework dimensions of appropriation

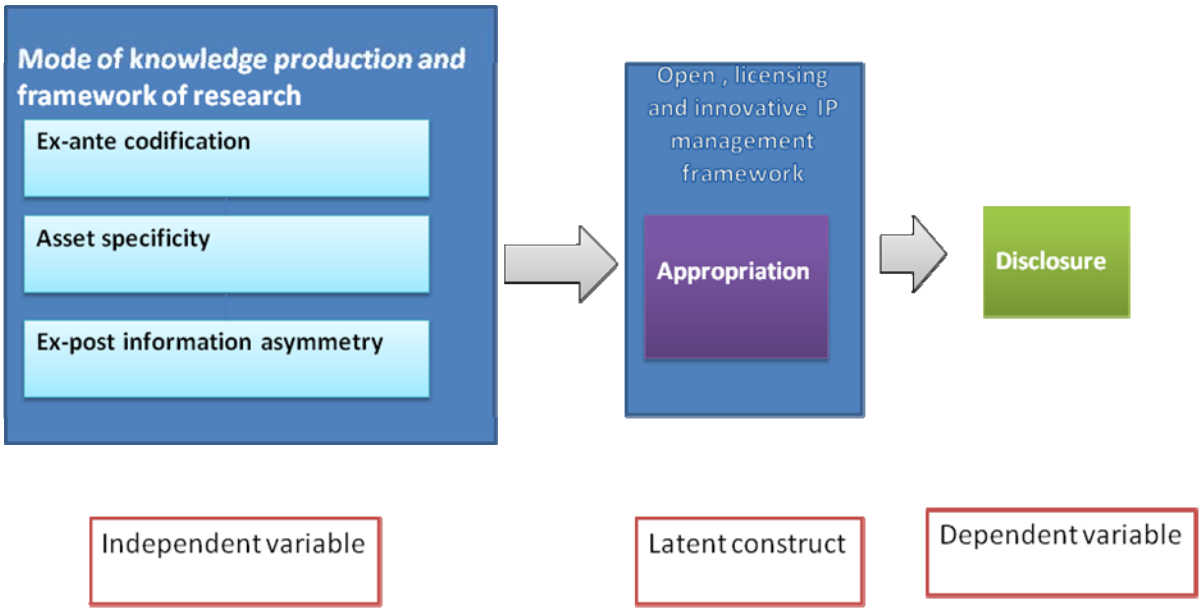

Figure 3: Research Model

The model of analysis proposed in this study aims to test the influence on IP of three proxies characteristics of knowledge (ex-ante codification, asset specificity and ex-post monitoring) that is development within the framework at Public research institutes (Mode 1, 2, and 3). The principal aim is to look at their effect on appropriation in view of three PRO models of appropriation (open, licensing and innovative models)